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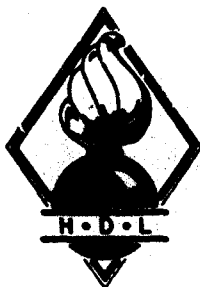
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**CONSTRUCTION DETAILS OF HDL
ARTILLERY SIMULATOR (PROTOTYPE)**

by
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ABSTRACT

Design data are presented on a prototype artillery simulator consisting of a 2-in. gun, a rotating tube or spinner, and auxiliary equipment. The system simultaneously applies linear and angular accelerations to a test vehicle to simulate the accelerations of an artillery round when fired from a rifled weapon. The spinner is designed to conduct one channel of electrical information from a component during a test.

1. INTRODUCTION

A system has been built for laboratory testing of fuzes or fuze components in a simulated artillery firing environment (fig. 1). The system differs from previous ones offering high acceleration or setback in that it also simultaneously provides high angular accelerations and velocities, by catching (decelerating) a high-velocity test vehicle in a rotating tube.

The initial high velocity is imparted to the test vehicle using a gun with a 33-ft long barrel and a 2-in. bore. The test vehicle with O-ring seals is placed in the breech and is held by a retractable firing pin. The muzzle is sealed with a cellulose acetate diaphragm and the barrel is evacuated. Pressure is applied using either air at atmospheric pressure or helium at pressures to 1000 psig. When the firing pin is retracted, the test vehicle is shot down the barrel through the diaphragm.

Two light-gas guns have been built at HDL (ref 1 and 2). Information gained in the construction and operation of those guns was used in the design of this gun.

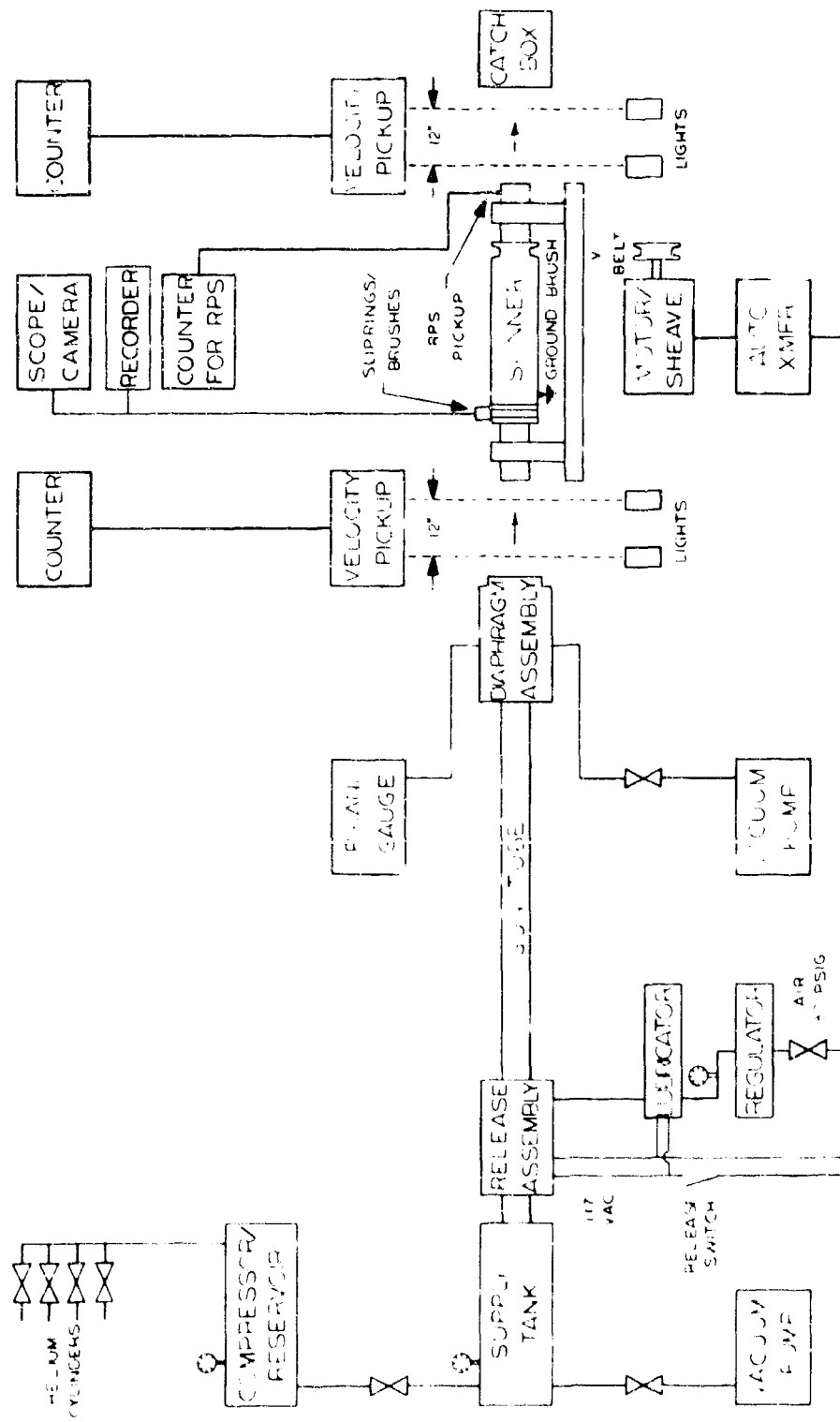
The spinner in which the test vehicle is decelerated is a tube 44-in. long with an inside diameter of 2 in. It is supported by bearings at the ends, is mounted in a heavy steel frame, and is belt-driven by a variable speed motor.

The method of operation and the initial results of the experiments with the simulator are covered in reference 3.

2. GUN

2.1 General

The principal components of the gun are a supply tank, a release assembly, a gun tube, and a diaphragm assembly. Supporting equipment includes a high-pressure system and two vacuum systems.



1437-67

Figure 1. Schematic of system.

The test item is contained in a test vehicle, which is held by a retractable pin in the barrel of the release assembly. The release assembly barrel is the breech of the gun tube. The diaphragm assembly is mounted at the muzzle of the gun tube with O-ring seals. A vacuum pump effects a vacuum in the gun tube prior to firing the test vehicle.

The test vehicle can be propelled in one of two ways depending upon the velocity desired. With the tube evacuated, atmospheric air may be used to propel the vehicle upon release. To meet higher velocity requirements, pressurized helium may be used. To use this method, the supply tank is attached to the assembly. Air in the tube and tank are evacuated with vacuum pumps. Helium is introduced into the supply tank to a pressure necessary to produce the proper velocity. A high-pressure compressor may be used to increase the pressure of the helium in the supply reservoir.

2.2 Supply Tank

The capacity of the supply tank (fig. 2) is 3.2 cu ft. Although the supply tank was not designed specifically for this job, it has proved adequate. It consists of an 11-in. diameter cylinder 45 in. long with dished end caps welded to each end. The wall is 1/2 in. thick throughout. The tank has been hydrostatically tested to 3000 psig. An adapter with a flange to match the flange of the release assembly has been fitted to the discharge end of the tank. The inside diameter of the adapter is 2 in. Supply lines, a 1000-psi compound gauge, and fittings for the vacuum pump complete the tank complement.

2.3 Release Assembly

The release assembly (fig. 3 and 4) is designed to retain the test vehicle against a maximum supply tank pressure of 1000 psig. It consists of a 2-in. i.d. tube 1 in. long with flanges, a support shell for a retractable pin connected to a piston, and a cylinder. The piston is air-actuated; an electrical solenoid actuates the valves supplying air to the piston. The pin, made from 3/8-in. diameter drill rod, extends approximately 1/2 in. into the side of the tube, and is sealed by an O-ring and vacuum oil. It was plated with electroless nickel to provide a low-friction surface to minimize sticking.

The air cylinder is flush-mounted and contains a double-acting piston 4 in. in diameter. The stroke of the piston is 1 in. End cushions within the cylinder minimize shock when the piston is actuated. The valves of the air cylinder are actuated by an electrical solenoid operating on 117 V ac. The air supplied to the

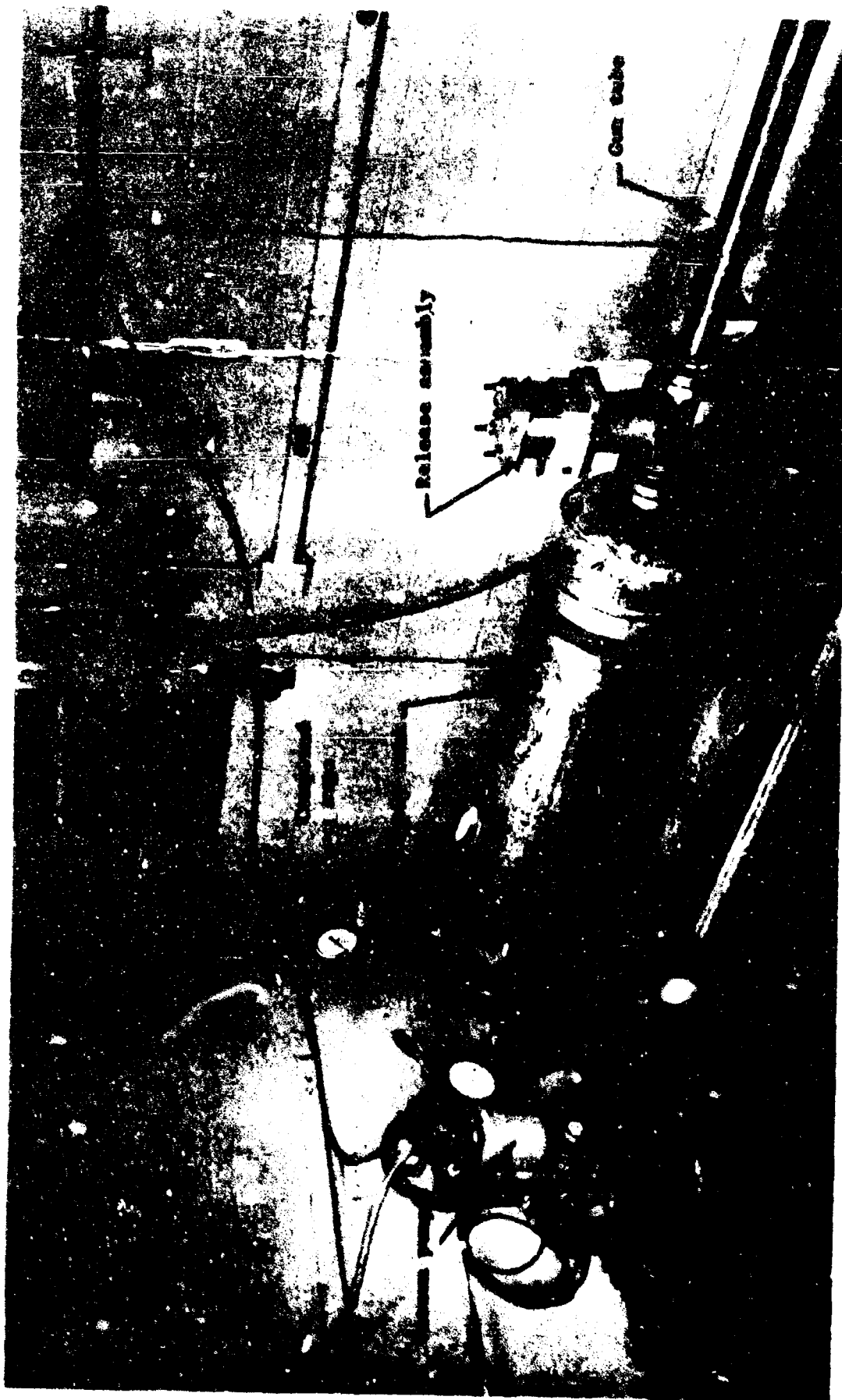
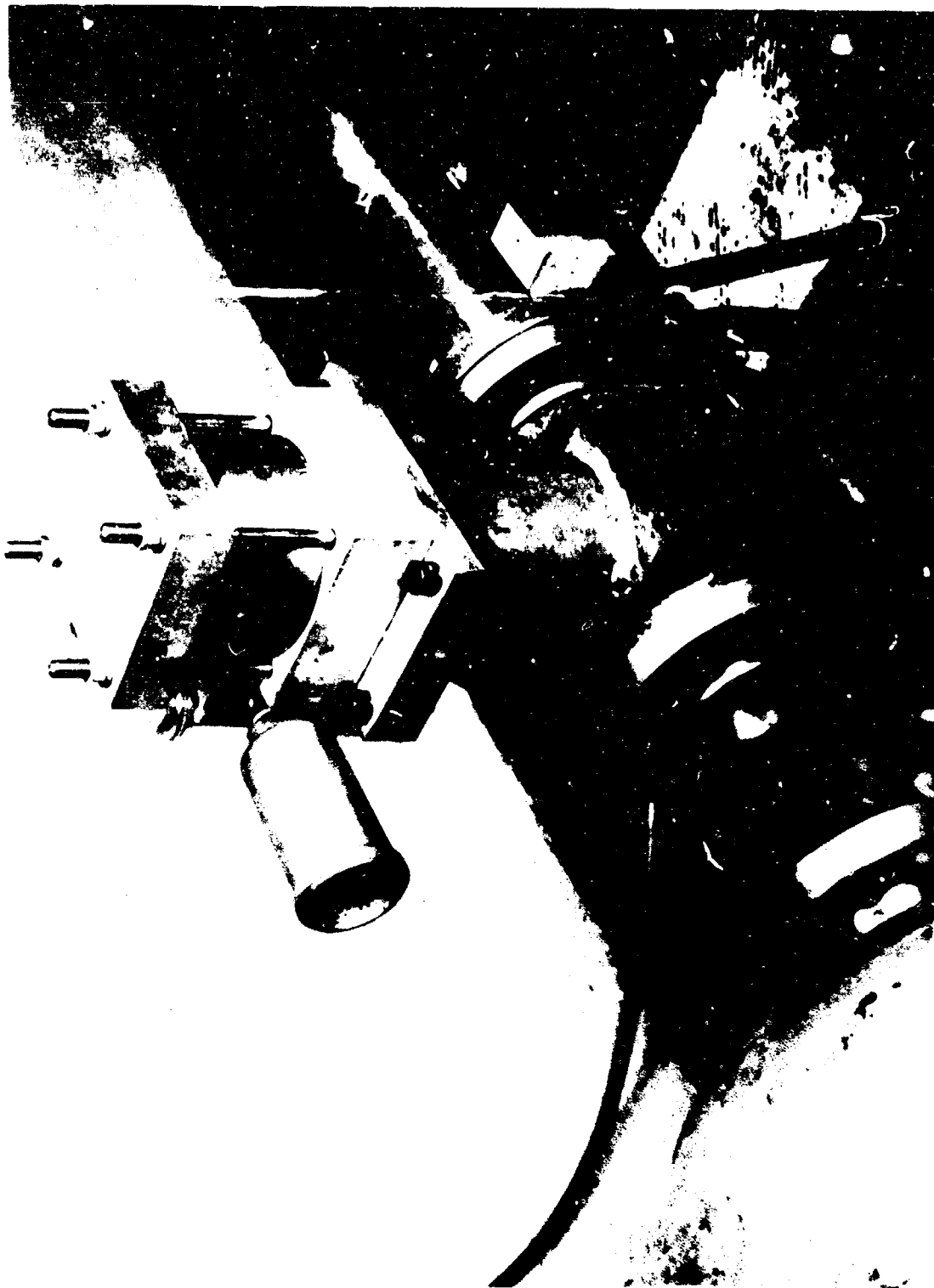
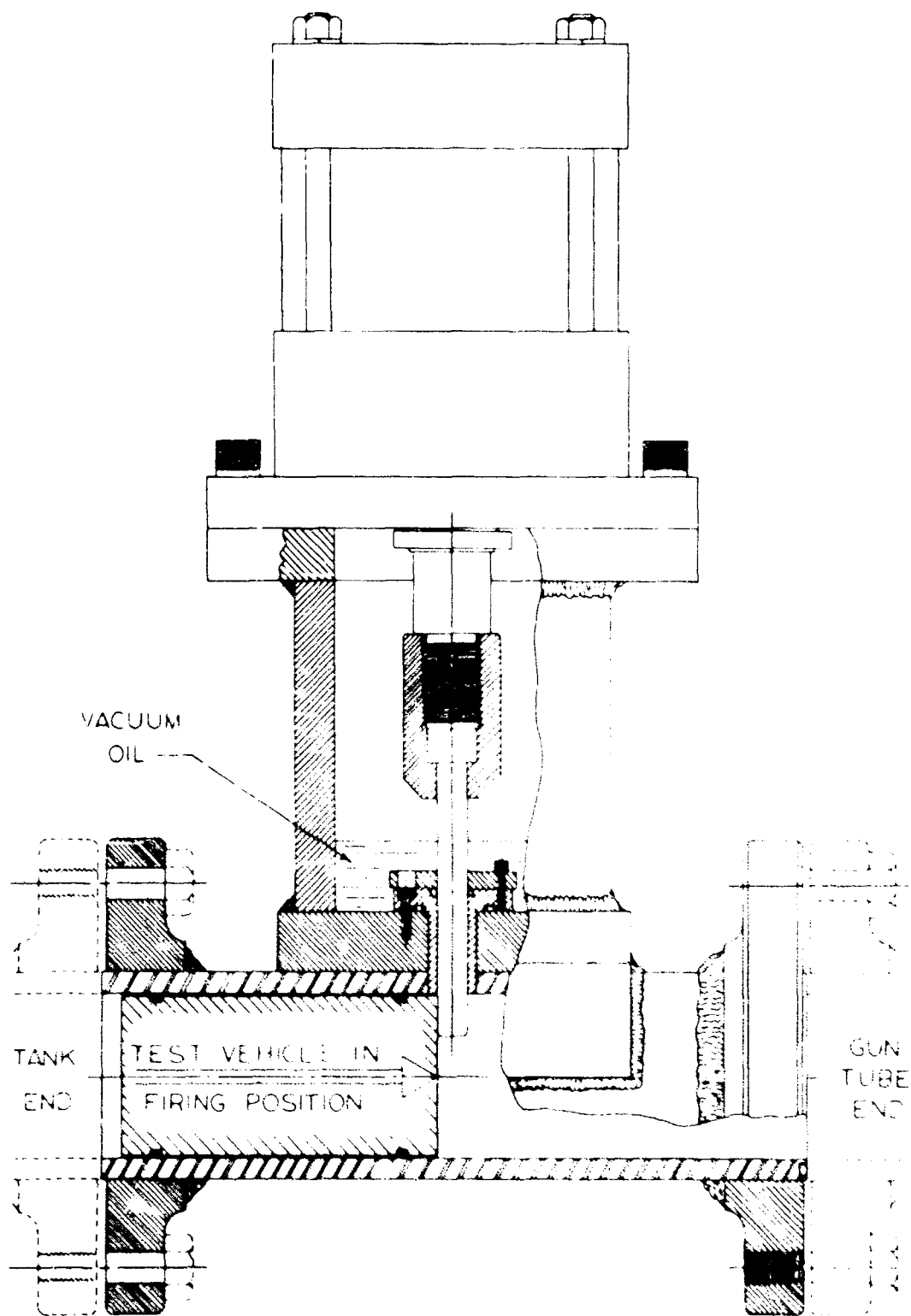


Figure 2. Supply tank and auxiliary equipment. 1121-65



1116-65

Figure 3. Release assembly.



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Figure 4. Sectional view of release assembly.

valves to actuate the piston is regulated at 80 psig. The control switch for the solenoid connected to the air input valves also energizes a lubricator solenoid which actuates a lubrication system for the piston and rod while they are operating.

The solenoid for the assembly is normally set so that the firing pin blocks passage of the test vehicle. Pressing the control switch on firing activates the solenoid, momentarily withdrawing the pin from the tube, releasing the vehicle.

2.4 Gun Tube

The 33-ft long tube for the gun (fig. 2) was made from two sections of seamless steel tubing joined together with a collar welded to each tube. The tube had a 2-in. inside diameter and 1/4-in. wall thickness. Flanges were welded on each end of the tube to match the flanges of the release assembly and the diaphragm assembly. Although a commercial carbon steel tube was used, the advantages of using a corrosion-resistant material, such as stainless steel, warrants consideration.

2.5 Diaphragm Assembly

The diaphragm assembly (fig. 5 and 6) is bolted to a flange at the muzzle end of the gun. Part of the assembly is a removable ring used to hold a diaphragm of cellulose acetate 5 mils thick in place. The diaphragm, which is ruptured by the vehicle as it leaves the gun, is replaced after each test.

O-rings with a suitable lubricant are used to assure an effective seal. The seal is adequate to permit evacuating the tube to a pressure of 10 to 100 μ Hg. The small quantity of air remaining in the tube at the time of firing is compressed in front of the test vehicle. As the vehicle approaches the diaphragm, the air can expand into the cavity in the assembly. This avoids premature rupturing of the diaphragm and allows the vehicle to sever the diaphragm cleanly.

2.6 High-Pressure System

Twenty-four helium cylinders arranged in four groups of six each are used to meet supply requirements. Initial pressure is about 1800 psig in each cylinder. Supply manifolds go from each bank to a compressor (fig. 7). The compressor discharges into a reservoir at a maximum pressure of 3000 psig. Suitable piping and control valves have been installed to supply the tank for the gun with helium from the reservoir.



Figure 5. Diaphragm assembly. 1119-65

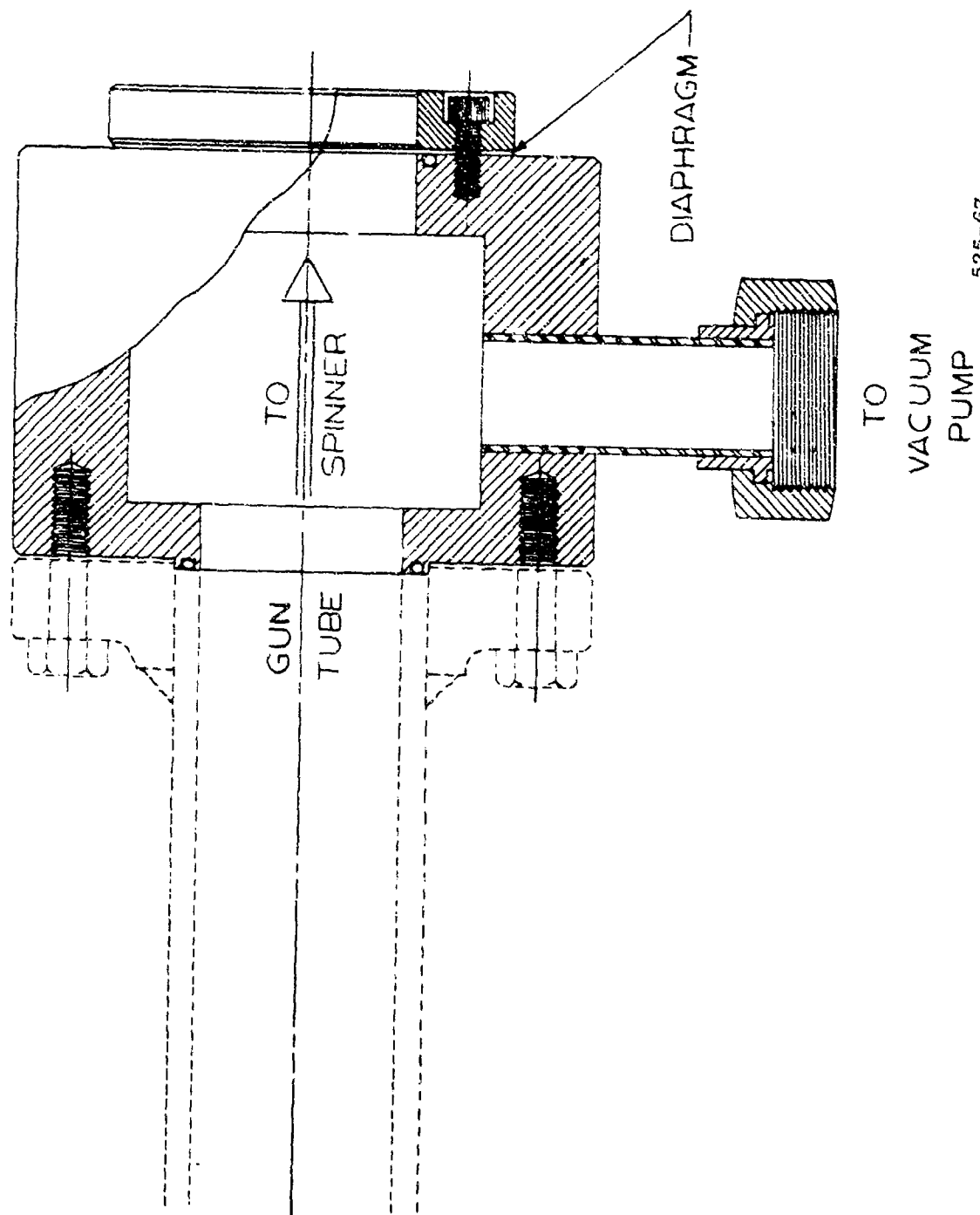


Figure 6. Sectional view of diaphragm assembly.

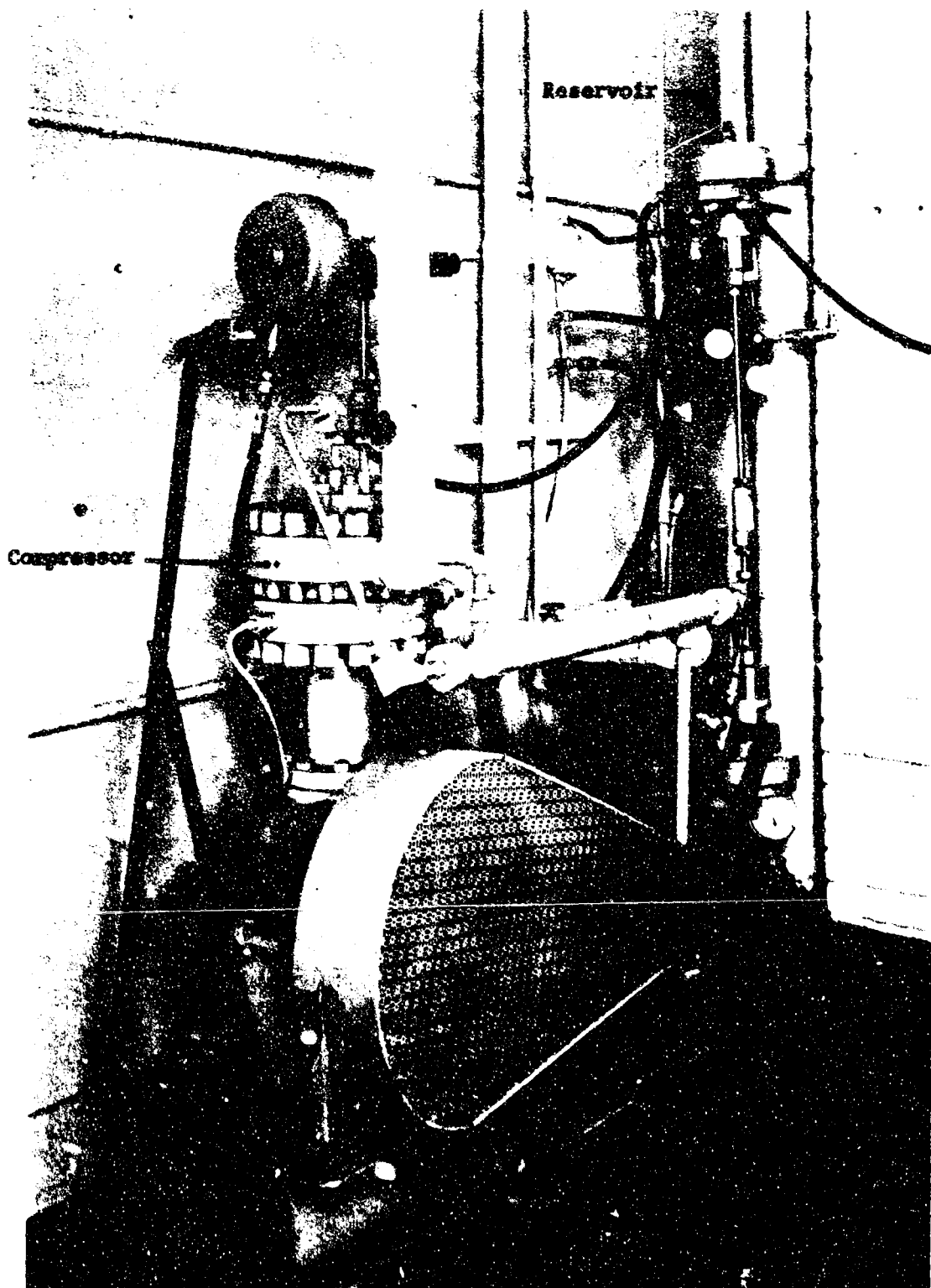


Figure 7. Helium compressor with reservoir. 1123-65

2.7 Vacuum Systems

It is necessary to remove the air from the supply tank for the gun prior to charging it with helium, to minimize dilution. The vacuum pump (fig. 2) used for this purpose removes the residual gas from the tank until the reading on the compound gauge stabilizes near 30 in. Hg vacuum.

A second vacuum pump (fig. 8) is used to evacuate the tube of the gun. A Pirani vacuum gauge is used to monitor the pressure within the tube prior to releasing the test vehicle. A pressure of 10 to 100 μ Hg is obtained before the vehicle is released.

All mating joints throughout the gun are sealed by O-rings with a suitable lubricant.

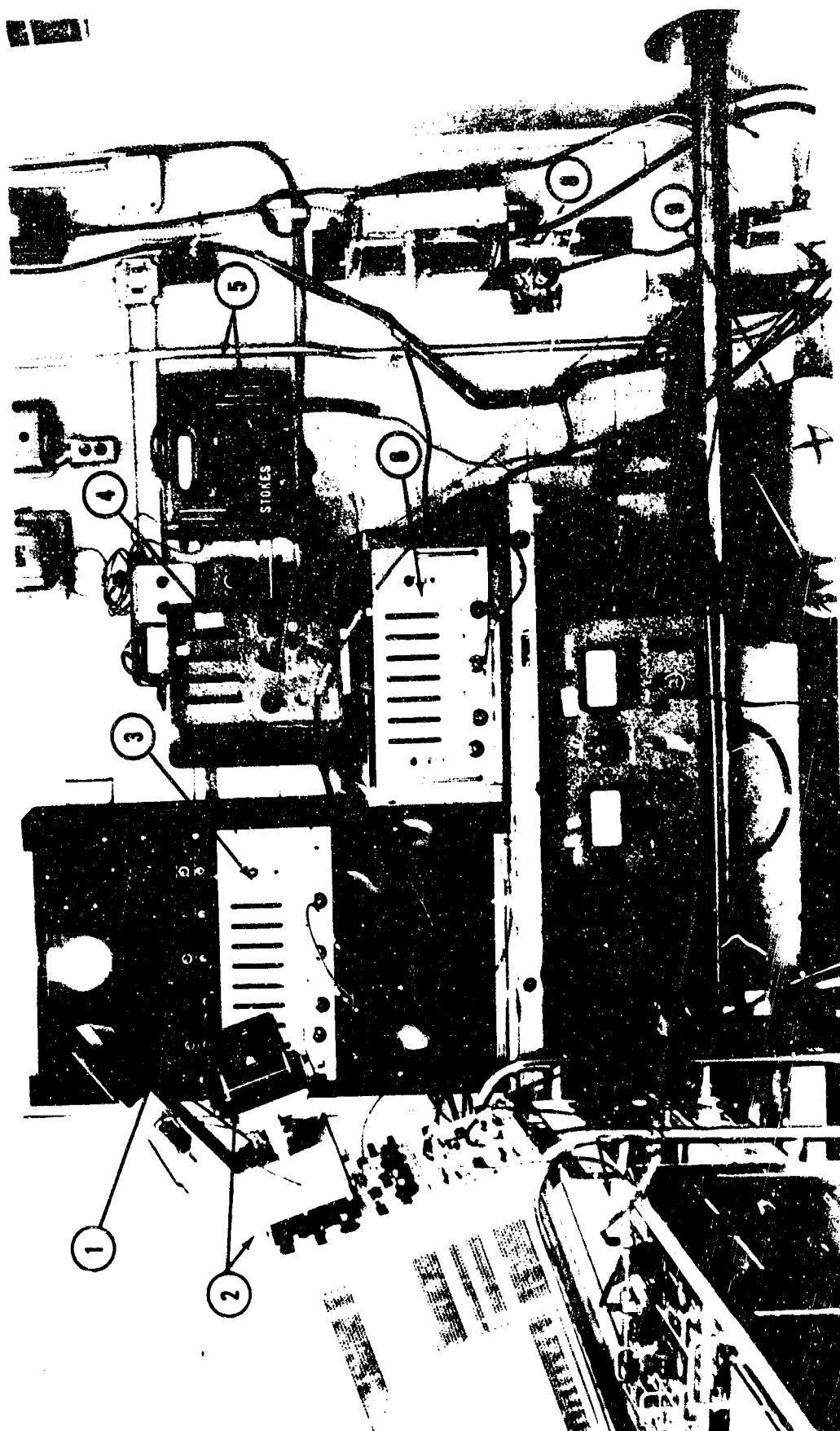
3. SPINNER

3.1 General

The spinner (fig. 9 and 10) is approximately 44 in. long. It is a tube with an inside diameter of 2 in. The selection of the 2-in. bore was a compromise involving two factors: the larger the tube diameter the fewer the limitations on test component size; however, a higher rotating speed is obtained with a smaller tube diameter because imbalance is minimized. A sheave is machined in the tube for a V-belt drive. A variable-speed 2-hp motor is used to drive the tube at the desired rate. The top speed of the motor limits the spinner to 5400 rpm. Plans for the future will include a larger motor and improved bearings on the spinner to increase its speed.

The tube rotates in 65-mm heavy-duty permanently lubricated bearings. The bearings are held in heavy metal supports at each end of the tube. The supports are firmly attached to a steel plate $1\frac{1}{2}$ in. thick, 8 in. wide by 40 in. long. The plate is mounted with adjustment screws to align the spinner with the muzzle of the gun. The distance from the muzzle of the gun to the spinner is approximately 14 in. This gap is used to disperse the gases behind the test vehicle.

The test vehicle is decelerated and stopped in the spinner within a few inches after impact with plywood blocks and a metal slug (fig. 11). These blocks absorb some of the energy of impact, and the remaining energy is transmitted to the hexagonal metal slug of predetermined mass. The metal is covered with a Teflon jacket



1120-65

Figure 8. Control equipment, instrumentation, and vacuum pump.

- | | | | |
|----------------------------|----------------------------|---------------------|------------------------------------|
| (1) Firing panel | (4) RPS meter | (7) Recorder | (10) Photo-multiplier power supply |
| (2) Oscilloscope/camera | (5) Vacuum gauges | (8) Autotransformer | |
| (3) Time-of-flight counter | (6) Time-of-flight counter | (9) Vacuum pump | |

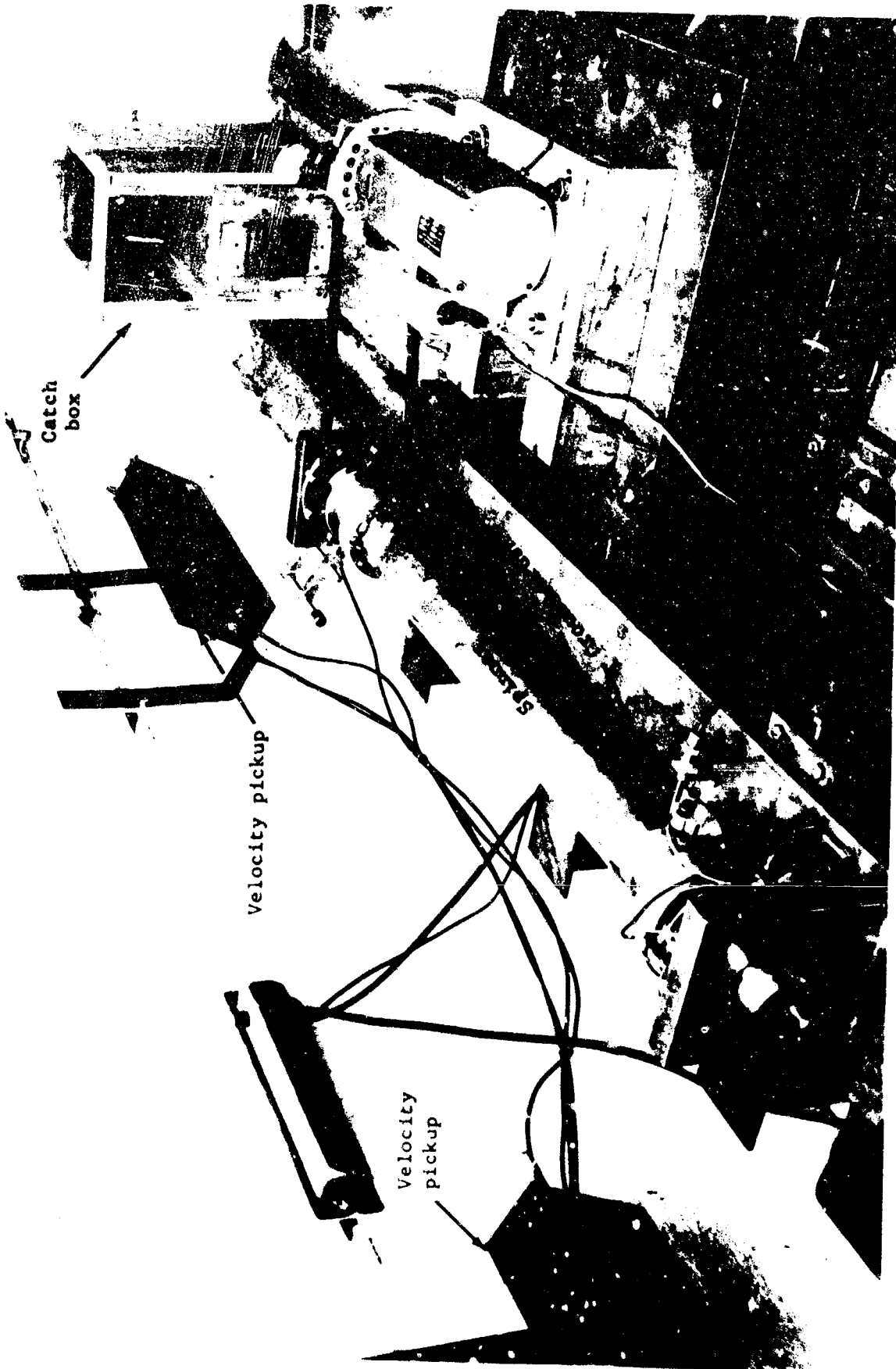


Figure 9. Spinner, drive system, and catch box.

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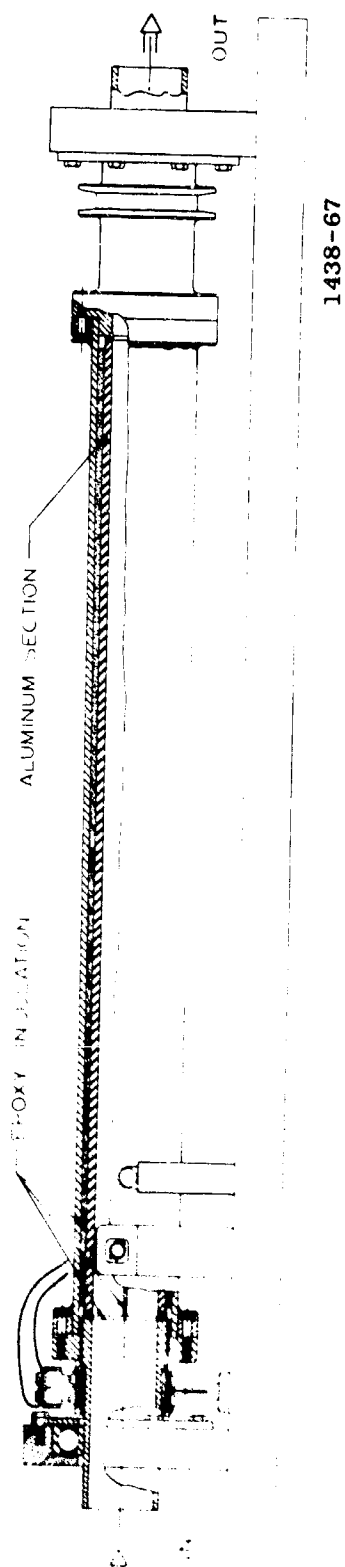


Figure 10. Sectional view of spinner.

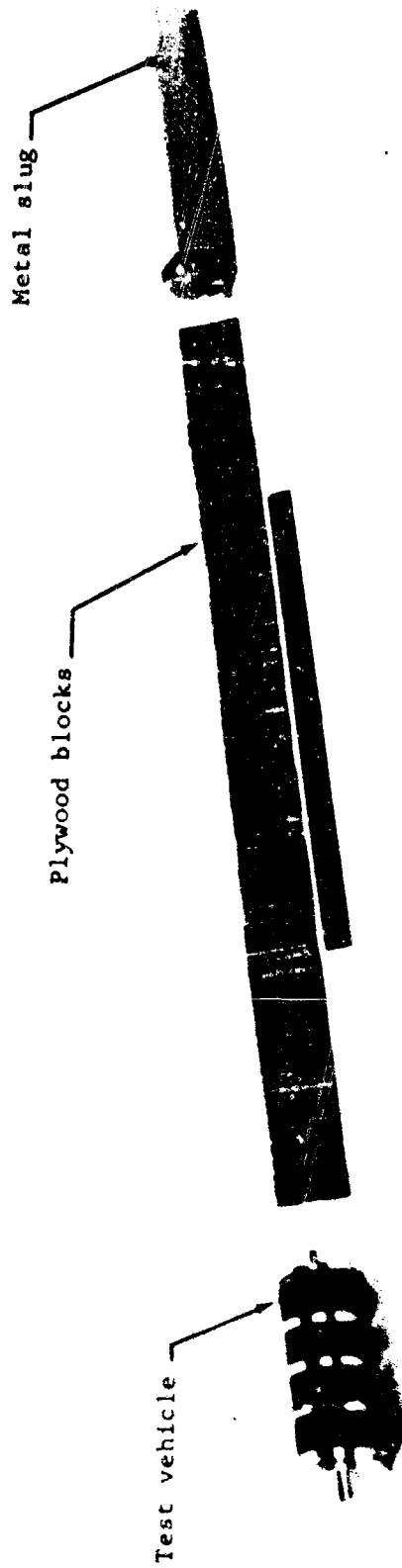


Figure 11. Test vehicle, plywood blocks, and metal slug.

for electrical insulation. The hexagonal shape of the metal allows air in front of the vehicle to pass around the metal slug. The wood blocks and the metal slug are ejected out the back of the spinner into lead plates in a catch box (fig. 9). The linear movement of the test vehicle is changed to the rotational speed of the spinner upon its deceleration at impact.

The linear velocity of the vehicle into the spinner and the velocity of the metal slug out of the spinner is checked by the interruption of beams of light to photomultiplier tubes. The apertures in each unit are 12 in. apart. There are two such units (fig. 9). The electrical information is sent to the time-of-flight counters (fig. 8).

3.2 Information Pickup

The central portion of the spinner consists of two semi-circular tubular sections designed to pick up one channel of information from the test vehicle. The sections were made by cutting an aluminum tube lengthwise. They have a wall thickness of 1/4 in., are 30 in. in length, and are held rigidly in position by epoxy to insulate them from the steel casing of the spinner and from each other. The thickness of the epoxy is 1/16 in. longitudinally between sections, 1/8 in. at each end of the sections, and 1/4 in. between the outer surface of the sections and the inner surface of the casing.

Two insulated lead wires pass through holes in the spinner casing 180 deg from each other connecting each section to a slip-ring. The sliprings and brushes are mounted adjacent to the bearing support at the entrance end of the spinner. The electrical information to each of the sliprings is picked up by three connected brushes; a set of three is used to minimize the effect of vibration. A lead wire from each of the brush assemblies to appropriate instrumentation completes the electrical circuit. An oscilloscope with camera and/or a recorder are used to collect the test data.

A single brush contacts a machined groove on the outer surface of the spinner. This brush has been mounted on a support stand and is wired to ground the spinner (fig. 9).

3.3 Motor, Drive, and Controls

The spinner is driven by a 2-hp d-c motor. The speed of the spinner is limited by the motor to 5400 rpm and is controlled by an autotransformer. The spinner has a machined flat spot on its outer surface for use with a variable reluctance pickup. The rate of the impulses representing rps is observed on an electronic counter.

The driven pulley is located just adjacent to the bearing support at the exit end of the spinner (fig. 9). It is machined as an integral part of the spinner casing. The motor drive system accommodates a 5/8-in. standard fiber V-belt on 17-in. centers. Each pulley has a pitch diameter of approximately $3\frac{3}{4}$ in.

4. TEST VEHICLE

One type of test vehicle is tubular with closed ends, has a groove at each end for an O-ring, is about 2 in. in diameter, 4 in. long, and weighs from 1 to 2 lb (fig. 11). The front cover is removable for easy insertion of the test item. The vehicle has a set of contacts 180 deg apart that move outward against the inside wall of the spinner when linear deceleration and angular acceleration are imposed upon impact. It is essential that each contact come to rest on a tubular section if electrical information is required from the item undergoing test. The vehicle is insulated to avoid shorting the sections.

5. REFERENCES

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(2) H. R. Kollmeyer, "Light-Gas Gun for Production of Shock Pressure in Solids," DOFL TR-933, 15 August 1961.

(3) Herbert D. Curchack, "An Artillery Simulator for Fuze Evaluation," HDL TR-1330, November 1966.

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| | Air gun, Gas gun | | | | | | |
| | Spinners | | | | | | |
| | Artillery simulation | | | | | | |
| | Impact | | | | | | |
| | Fuze testing | | | | | | |
| | Setback | | | | | | |
| | Spin catcher | | | | | | |